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Effects of different gas compositions on the color estimations of MAP packaged pork chops

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Abstract

This study was conducted to observe effects of different gas compositions on color of pork chops packaged in modified atmospheres. Gaseous compositions used were: MAP1 (75% O_2:25% CO_2); MAP2 (70% O_2:30%CO_2) and MAP3 (80% O_2:20% CO_2). Sensory evaluations of meat color and chemical properties (acid number, peroxide value, a_w, pH, TVB-N and TBARs), were carried on the 1st, 5th, 7th, 9th and 12th day of storage. The sensory evaluations of chop color in different MAP compositions are analyzed in relation to storage period, measured chemical properties and instrumental determination of meat color using linear and multivariate linear regression analysis.

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Keywords: MAP; pork chops; meat color; sensory evaluation; chemical changes

1. Introduction

Modified atmosphere packaging (MAP) is widely used to maximize meat shelf life and maintain its attractive fresh appearance. During the past two decades MAP has become significant and increasingly popular technology in the area of retail meat packaging.[1] There are three gases which are mainly used in MAP, i.e. oxygen (O_2), carbon

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dioxide (CO_2) and nitrogen (N_2). Meat purchasing decisions are influenced by color more than any other quality factor because consumers use discoloration as an indicator of freshness and wholesomeness.[2] Color, lipid oxidation, and microbial criteria are the most important quality criteria for storage of fresh red meat. Therefore, the modified atmosphere packaging must stabilize both the color and oxidation, as well as retard the microbial growth. It is common that 20–30% CO_2+70–80% O_2 in conventional gas composition of modified atmosphere is used for packaging of fresh red meat.[3] Oxygen is required for myoglobin–the principle protein responsible for the meat color[2] to keep it in oxygenated form, which gives the bright cherry red color to meat. While the use of high oxygen concentration is known to prolong the color stability by promoting the formation of oxymyoglobin, it is also expected to increase the rate of lipid oxidation[4] which causes undesirable changes in color and flavor.

In this research, the aim was to determine the effects of three different gas compositions on color properties and chemical changes of pork chops.

2. Materials and methods

For analyses in this study, *Mm. longissimus dorsi* of normal quality, from the left and right halves of pigs (n = 7), were used. After processing, approximately 24 h post mortem, muscle without bone and fat was cut into 20mm thick chops. Packaging units used for pork chops were: the upper foil, F type LID HB-S (producer: Spektar–Gornji Milanovac, Serbia); Characteristics of lid film: Oxygen Transmission Rate (OTR) <15 cm^3/m^2, 24 h, atm; Water Vapour Transmission Rate (WVTR) <15 g/m^2 24 h, atm and polystyrene containers (HIPS, LDPE and XPS) with EVOH layer, black coloured, 290 x 215 x 40 mm, produced in Italy. Packaging was conducted in the apparatus CAVECO LC1. Compositions of the gas mixture were: (MAP1) 75% O_2:25% CO_2; (MAP2) 70% O_2:30% CO_2 and (MAP3) 80% O_2:20% CO_2. Applied pure gasses were of food grade (Messer, Austria).

Packed chops harvested from the pig halves were stored between 1.5°C and 4°C. Color evaluation of packaged fresh meat was performed on the day of packaging (1) and after 5, 7, 9 and 12 days of storage.

Sensory color evaluation of fresh meat was performed by a panel of seven experienced members. Color was evaluated using a point system of analytical descriptive tests with a scale of 1 to 5, according to ISO 6658:2001[5] where the optimal color was given a 5 (reddish pink) and unacceptable color was given a 1 (pale pinkish grey).

During the storage of the meat, parameters that show hydrolytic and oxidative rancidity were determined. Acid number (AN) was determined by standard method EN ISO 660:2009[6], peroxide number by standard method EN ISO 3960:2010[7], and thiobarbituric acid reactive substances (TBARS) were detected by help of tests for determination of oxidative rancidity in foods[8,9] . pH value of samples was measured by laboratory pH-meter, model Cyber Scan, pH 510 Meter (EUTECH Instruments, Netherlands) according to standard method ISO 2917:1999[10], and a_w value was measured by hygrometer (aw meter FAst/1, GBX Scientific Instruments) according to standard ISO 21807:2004(E) method.[11] TVB-N (Total Volatile Basic Nitrogen) was determined according to the method proposed by Official Journal of the European Union[12] (2005).

The instrumental (objective) surface color of fresh meat was measured after opening the packaging units, in triplicate on each sample, by a Minolta Chroma Meter CR-400 (Minolta Co., Ltd., Osaka, Japan) using D-65 light source, a 2° standard observer angle and an 8mm aperture in the measuring head.

Color characteristics are given in the Commission Internationale de l'Éclairage's[13] (CIE) L*a*b* system. Results were expressed as lightness (L*), redness (a*) and yellowness (b*).

2.1. Statistics

Results of sensory, instrumental and chemical evaluations of packaged pork chops were processed using descriptive statistics (MS Excel). Linear regression and multivariate regression were used to examine relationships among chemical parameters to the value of sensory estimations of color during storage periods. For each variable, regression coefficients were calculated, as well as their statistical significance. The effect of each predictor (chemical and instrumental color parameters) on the dependent variable (sensory evaluation of meat surface and cut color) was estimated. Results of descriptive statistics were expressed as a mean value±standard deviation (SD). Statistical significance of means between data sets determined using ANOVA and post-hoc Tukey`s test. Statistical analysis was performed by the JMP 10 software package (SAS Institute, USA).

3. Results and discussion

Results of sensory color estimations of MAP packaged pork chops in different gas compositon atmospheres during the study are shown in Table 1.

Table 1.Sensory estimation of pork chop color packaged in different MAP composition types.

	MAP1 75% O_2:25% CO_2		MAP2 70% O_2:30%CO_2		MAP3 80% O_2:20% CO_2	
Day	surface color	cut color	surface color	cut color	surface color	cut color
1	4.29 ± 0.25^{AB}	4.29 ± 0.25^{a}	4.42 ± 0.26^{A}	4.46 ± 0.29^{a}	4.00 ± 0.22^{B}	4.13 ± 0.26^{a}
5	3.54 ± 0.33^{B}	3.54 ± 0.33^{b}	4.25 ± 0.22^{A}	4.33 ± 0.20^{a}	3.38 ± 0.26^{B}	3.46 ± 0.29^{b}
7	3.29 ± 0.29^{B}	3.29 ± 0.29^{b}	3.83 ± 0.20^{A}	4.00 ± 0.22^{a}	2.33 ± 0.20^{C}	2.46 ± 0.19^{c}
9	2.63 ± 0.21^{B}	2.67 ± 0.20^{b}	3.71 ± 0.25^{A}	4.00 ± 0.22^{a}	2.17 ± 0.20^{C}	2.21 ± 0.19^{c}
12	2.13 ± 0.21^{B}	2.25 ± 0.32^{b}	3.29 ± 0.19^{A}	3.46 ± 0.29^{a}	1.00 ± 0^{C}	1.00 ± 0^{c}

* Means that do not share a letter are significantly different (ABC-surface color; abc- cut color; $p < 0.05$).

Looking at results given in Table 1, the lowest loss in color appearance is attributed to MAP2 and the greatest to MAP3. Five days after storage, MAP2 packaged chops, regarding the surface and cut color estimate were significantly different from other two ($p < 0.05$). Between MAP1 and MAP3 after five days of storage, there were no registered significant differences ($p > 0.05$). Starting from the 7th day, significant differences in meat color between presented MAP composition types were visible. The worst estimation regarding surface and cut color of MAP packaged chops was registered in MAP3. On the other hand, MAP2 had the best sensory estimations of surface and cut color (Table 1) throughout the storage period. Twelve days after storage, the chops in MAP3 were declared as unacceptable, and these results were not further statistically treated.

Linear regression analysis of sensory evaluations of color MAP packaged chops (surface and cut) in relation to the observed storage period (12 days) generally, showed more or less sharp linear declines in relation to MAP gas composition. These differences between numerical values of slope constants are presented in Table 2.

Table 2. Slope constant values in different MAP compositions.

MAP composition	slope constant (chop surface)	slope constant (chop cut)
MAP1	-0.20	-0.19
MAP2	-0.10	-0.09
MAP3	-0.25	-0.25

Slope constants can be considered as meat color change rates and loss of visual acceptability from consumer point of view. Meat purchasing decisions are influenced more by color than any other quality factors.[14] Summing it up, the slowest changes in color appearance were registered in MAP2, while the MAP3 compositon had the greatest rate of color loss. Peroxide number values did not change during the storage period, and hence, they were not included in data processing. In all applied MAP mixtures, significant increases in pH values were registered at the end of the storage period (12^{th} day). Multivariate linear regression was shown to produce high coefficients in determination of relationships among examined chemical parameters on the values of sensory estimations of color during observed storage period. In the obtained models, determination coefficients were: MAP1 ($R^2 = 0.90$ and 0.88 for surface and cut color, respectively); MAP3 ($R^2 = 0.92$ and 0.93), MAP2 (R^2=0.74 and 0.66). Some chemical parameters estimated and sorted as a significant in whole model contribution ($p < 0.05$) were: in MAP1 (AN, TBARS) both for the meat surface and cut color; in MAP2 (AN, TBARS, pH and TVB-N); in MAP3 (pH and a_W). Other chemical parameters did not have a significant influence on sensory estimations of meat color (both surface and cut) in the obtained regression models in relation to particular MAP packaging compositions. Estimated contributions ($p < 0.05$) using multivariate linear analysis of relationships between sensory estimations of meat color and instrumentally measured color parameters (L*a*b* system) were: for MAP1 (a*,b*) both for the meat surface and cut color; for MAP2 (a*); for MAP3 (L*, b*). Also a statistically significant difference ($p < 0.05$) was registered regarding the L* value in MAP2 packages (L=45.1) in relation to other two: MAP1 (L*=55.4); MAP3 (L*=58.6) a day after packaging in the meat processing facility. Although the muscles did not differ in chemical composition, both the initial a* and b*-value and the colour fading during storage varied between the studied MAP compositions.

The cause of registered variations might arise from differences in the amount of enzymes present in muscles, which are capable of regenerating the pigment and thereby the pink colour.[15]

4. Conclusions

Visual sensory evaluations of meat color, rated from 1 to 5 were well correlated with and supported by instrumental determination using the L*a*b* system.

It can be pointed that sensory evaluations of observed retail MAP formats have been dependent upon product random variation, package, and system interactions.

Although examined chemical parameters critical for the sensory estimation of meat colour have been studied and certainly found to be crucial (statistically), from the results obtained, it can be concluded that the observed parameters interact in a complex way influencing the product colour.

Taking into account sensory and instrumental estimations of meat color it seems that MAP2 (70% O_2:30%CO_2) composition,in this case, represents an optimal solution for retail packaging of pork chops.

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References

1. Radetic P, Milijasevic M, Jovanovic J, Velebit B. Modified atmosphere packaging for fresh meat – trend that lasts. *Tehn mesa* 2007;**48**:99-108.
2. Mancini RA, Hunt MC. Current research in meat color. *Meat Sci* 2005;**71**:100–21.
3. Esmer OK, Irkin R, Degirmencioglu N, Degirmencioglu A. The effects of modified atmosphere gas composition on microbiological criteria, color and oxidation values of minced beef meat. *Meat Sci* 2011;**88**:221–26.
4. Cayuela JM, Gil MD. Effect of vacuum and modified atmosphere packaging on the quality of pork loin. *Eur Food Res Technol* 2004;**219**:316−20.
5. ISO 6658:2001. Sensory analysis -Methodology - General guidelines, Geneva, Switzerland: ISO/IEC.
6. EN ISO 660:2009. Animal and vegetable fats and oils – Determination of acid value and acidity, Geneva, Switzerland: ISO/IEC.
7. EN ISO 3960:2010. Animal and vegetable fats and oils- Determination of peroxide value-Iodometeric (visual) end point determination, Geneva, Switzerland: ISO/IEC.
8. Tarladgis BC, Pearson AM, Dugan LR. Chemistry of the 2-thiobarbituric acid test for determination of oxidative rancidity in foods. II Formation of the TBA malonaldehyde complex without acid heat treatment. *J Sci Food Agr* 1964;**15(9)**:602-7.
9. Holland CD. Determination of malonaldehyde as an index of randicity of nut meats. *Journal of AOAC* 1971;**54**:1024-26.
10. ISO 2917:1999. Meat and meat products – Measurement of pH (reference method), Geneva, Switzerland: ISO/IEC.
11. ISO 21807: 2004(E). Microbiology of food and animal feeding stuffs-Determination of water activity, Geneva, Switzerland: ISO/IEC.
12. Official Journal of the European Union (2005). Commission Regulation (EC) No 2074/2005. Determinationofthe concentration of TVB-N in fish and fishery products. Chapter III, L 338/37-338/39.
13. CIE. Official Recommendation of the International Commission on Illumination.Publication CIE No. E-1.31, CIE,Paris, 1976.
14. Nannerup LD, Jakobsen M, Van den Berg F, Jensen JS, Miller JKS, Bertelsen G. Optimizing colour quality of modified atmosphere packed sliced meat products by control of critical packaging parameters. *Meat Sci* 2004;**68**:577–85.
15. Taylor AA. Packaging fresh meat. In:Lawrie R, editor. *Developments in meat science*. London: Elsevier Applied Science; 1985. p. 89–113.